STATE OF VERMONT
PUBLIC SERVICE BOARD

Docket No. 6860

Petitions of Vermont Electric Power Company, Inc. ("VELCO") and Green Mountain Power Corporation ("GMP") for a Certificate of Public Good authorizing VELCO to construct the so-called Northwest Vermont Reliability Project, said project to include: (1) upgrades at 12 existing VELCO and GMP substations located in Charlotte, Essex, Hartford, New Haven, North Ferrisburg, Poultney, Shelburne, South Burlington, Vergennes, West Rutland, Williamstown, and Williston, Vermont; (2) the construction of a new 345 kV transmission line from West Rutland to New Haven; (3) the construction of a 115 kV transmission line to replace a 34.5 kV and 46 kV transmission line from New Haven to South Burlington; and (4) the reconductoring of a 115 kV transmission line from Williamstown, to Barre, Vermont

DIRECT TESTIMONY OF
GEORGE E. SMITH
ON BEHALF OF THE
VERMONT DEPARTMENT OF PUBLIC SERVICE

December 17, 2003

Summary: The purpose of Mr. Smith's testimony is to describe his review and technical evaluation of VELCO's proposed NRP from a transmission perspective and to provide

conclusions and recommendations resulting from this review.

Direct Testimony
of
George E. Smith

Identification of Witness and Qualifications

Q. Please state your name, position, and qualifications.

A. My name is George E. Smith and I am a professional engineer licensed by the State of Vermont (registration No. 7486). I have degrees in electrical engineering with 22 years experience in power transmission systems in areas including system planning, system protection and management of transmission engineering, construction and maintenance. I have worked as a consulting engineer since June of 2000. I also serve as a member on the executive committee of the New York State Reliability Council. My resume is attached as Exhibit DPS-GES-1.

Q. Have you testified before this Board before?

A. Yes. I have testified on behalf of VELCO on previous occasions regarding the emergency restoration of the PV20 circuit resulting from ice damage, Docket No. 5742; the installation of the PV20 causeway cable, Docket No. 5778; and the installation of the VELCO Essex substation flexible alternating current transmission system (FACTS) device and associated substation upgrade, Docket No. 6252.

Overview

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe my review and technical evaluation of VELCO's proposed NRP from a transmission perspective, and to provide conclusions and recommendations resulting from this review.

Q. As part of your review of the proposed NRP, what questions did you seek to answer?

A. I sought to answer the following:

1) Is the project needed for reliability?

2) Does the project as proposed meet this need?

3) Does the project meet this need in a least cost fashion?

4) Have transmission alternatives been adequately considered?

5)What are the impacts of the project on reliability and stability?

6) What are the operational impacts of the project?

7) Is the proposed construction sequence optimal?

8) What is the impact of the project on efficiency in terms of losses? And

9) What are the implications of the August 14, 2003 blackout on the proposed NRP?

Q. What sections of 30 V.S.A. § 248 are addressed by your testimony?

A. My testimony will address 30 V.S.A. § 248 (b)(2), the so-called least-cost criteria; 30 V.S.A. § 248 (b)(3), stability and reliability; and 30 V.S.A. § 248 (b)(4), economic benefit to the state. Regarding 30 V.S.A. § 248 (b)(2) and 30 V.S.A. § 248 (b)(4), I will testify that, generally, VELCO's proposed NRP provides the greatest benefits with respect to costs among the available transmission solutions, and that the NRP is required to provide Vermonters with reliable electric power, thereby providing benefits to the state and its residents. Sections 30 V.S.A. § 248 (b)(2) and 30 V.S.A. § 248 (b)(4) will also be addressed by Department witness Jonathan Lesser. Department witness Ronald Behrns will also address criterion 30 V.S.A. § 248 (b)(4). Regarding 30 V.S.A. § 248 (b)(3), I will testify that the proposed NRP is required for the reliability of the Vermont transmission system and that the project would enhance system stability.

Q. Please describe the work that you performed in reviewing VELCO's NRP proposal.

A. My work included the following:

1) a detailed review of VELCO's assumptions regarding availability of key resources and transmission elements including outage causes and likely durations;

2) a detailed review of the contingencies studied by VELCO including identification of

those causing major adverse reliability impacts;

3) a review of load duration information to determine the degree of reliability exposure;

4) a review of load characteristic assumptions used by VELCO in their analysis;

5) a review of post contingency performance criteria used by VELCO for consistency with regional practices;

6) a review of major transmission elements including lines, phase angle regulators (PARs), static compensators (STATCOMs), and transformers that were proposed by VELCO as components of the NRP;

7) a detailed review of substation bus, breaker and equipment configurations proposed by VELCO for the NRP; and

8) a detailed review of VELCO's analysis results and conclusions.

Q. How did you accomplish your work?

A. To accomplish my work, I performed the following:

1) I performed a detailed review of VELCO's direct testimony and exhibits prepared for this docket.

2) Working with DPS staff, I prepared discovery questions to gain additional information on VELCO's work and further explore transmission alternatives. And

3) Working with DPS staff, I organized and participated in informal discovery meetings with VELCO to gain additional information and further explore transmission alternatives.

Summary of Conclusions

Q. Please summarize the conclusions that you reached as a result of reviewing the proposed project.

A. A summary of my conclusions are as a follows:

1) Substantial transmission reinforcements are needed, absent extensive demand-side management (DSM) and newly installed generation, to provide first contingency

coverage and to reliably serve Vermont's customers for both today's load levels and to serve peak load levels up to 1200 MW.

2) If substantial transmission reinforcements are not provided, the Vermont electric system is prone to experiencing severe problems upon first contingency for a number of key transmission circuits. These problems would likely be widespread over Vermont and include severe voltage sags, loss of customer load, circuit overloads and possibly widespread voltage collapse.

3) At today's load levels, a portion of the proposed NRP additions is essential to insure adequate reliability. These include phase-angle regulating transformers (PARs) at the Blissville and Granite substations, the 115 kV line upgrade from New Haven to the Queen City substation, the first stage of static compensators (STATCOMs), and other improvements at the Granite substation.

4) For load levels up to 1200 MW, the remainder of the proposed NRP additions are required to insure adequate system reliability. These include the 345 kV line addition from West Rutland to New Haven, the associated New Haven substation additions, and the second stage of STATCOM at the Granite substation.

5) The NRP is superior to all available transmission alternatives.

6) VELCO's reliance in its planning process on the use of dynamic shunt compensation to provide voltage support and phase angle regulators (PARs) to control power flows raised some concerns. However, VELCO's reliance on these devices has no material effect on the proposed project.

7) The proposed Granite substation upgrades contain an inadequate footprint for the two stages of STATCOM and an inadequate design for connecting reactive power resources to the 115 kV bus. The proposed design for connecting reactive power resources to the 115 kV bus has an adverse effect on reliability and maintainability.

8) Cost estimates for the NRP are generally reasonable and reflect least cost transmission design while adhering to established reliability standards. The designs are efficient and show no evidence of "gold plating."

9) Cost estimates for the West Rutland to New Haven 345 kV transmission line and for the Granite substation additions are low. However, corrected cost estimates do not alter my conclusions with respect to the NRP.

10) Regarding the proposed New Haven to Queen City transmission line design:

A) The proposed design represents the most efficient electrical design available, affords a high level of reliability for the customers supplied by the distribution substations in this corridor, and affords significant loss savings.

B) The proposed overhead, single pole design, is simple, reliable, safe and lends itself to further reduction in pole height and conductor spacing.

C) The design, from a construction stand point, represents least cost design with regard to Vermont ratepayers, saving approximately $1M over the leading alternate.

11) Regarding the West Rutland to New Haven transmission line design:

A)The proposed 345 kV H-frame construction achieves a least construction cost solution while offering adequate reliability and minimum structure height.

B) Corridor width expansion can be minimized by use of single pole configurations.

C) For most or all of the line length, it is possible to reduce the corridor expansion by simply locating the new H-frame 345 kV structures closer to the existing 115 kV H frame structures. A reduction of up to 25 ft. may be possible. There is no significant cost impact. Maintenance impacts require further evaluation.

12) Undergrounding of the proposed transmission lines is not recommended due to adverse cost, reliability, and environmental impacts.

13) Generally, the NRP as proposed by VELCO represents a well conceived reliable design, compliant with standards used for bulk transmission throughout the Northeast.

14) Stability of the electric system with addition of the NRP will be significantly enhanced.

15) The NRP will provide numerous major benefits to operation of the VELCO system.

16) The proposed NRP is safe, and enhances safety in the existing New Haven to Queen City substation corridor.

17) Considerations by VELCO of audible noise impacts of the NRP are incomplete.

18) VELCO's construction sequencing plan is appropriate.

19) The proposed NRP would provide for a reduction in electric system losses.

20) The events of the August 14, 2003 blackout have no impact on the conclusions reached regarding the need or the adequacy of the design of the NRP.

21) The NRP provides a platform for upgrading the transmission system to reliably serve load levels beyond 1200 MW in that all components proposed by VELCO would be required in any future transmission system expansion scenarios needed for reliability.

Summary of Recommendations

Q. Please summarize the recommendations that you have as a result of reviewing the proposed project.

A. A summary of my recommendations are as a follows:

1) Regarding VELCO's proposed upgrades to the Granite substation, and prior to the issuance by the Board of a certificate of public good in this case, the Board should require VELCO to:

A) distribute some of the fixed capacitors proposed for this substation to other locations on the 115 kV ring bus;

B) connect the two 75 MVAR STATCOM modules into the bus work with separate 115 kV breakers;

C) review and update the STATCOM cost estimate in order to accommodate any of the available dynamic reactive voltage support technologies; and

D) update the estimate of the total cost of the Granite expansion and equipment additions.

These recommendations are discussed in further detail under the heading Reliability and Stability in this testimony.

2) I recommend that the use of underground cable as a component in the NRP be avoided. This is discussed in further detail under the heading Underground Considerations in this testimony.

3) Regarding the proposed 115 kV transmission line between New Haven and the Queen City substation, the Board should require VELCO to utilize the transmission structure alternatives discussed in this testimony under the heading Alternative Structure Configurations for the New Haven to Queen City 115 kV Line, for the purpose of aesthetic mitigation, in those locations identified by Department witness David Raphael.

4) Regarding the proposed 345 kV transmission line between West Rutland and New Haven, the Board should require to VELCO utilize the transmission structure alternatives discussed in this testimony under the heading Alternatives for the West Rutland to New Haven 345 kV Line, for the purpose of aesthetic mitigation, in those locations identified by Department witness David Raphael.

5) For the 1.3 miles of the proposed 345 kV transmission line between West Rutland and New Haven where VELCO currently plans to expand its ROW beyond 150 ft., the Board should require VELCO to consider the adoption of Alternatives 1, 2 and 4 as discussed in this testimony under the heading Alternatives for the West Rutland to New Haven 345 kV Line.

6) Regarding audible noise from substations, the Board should require VELCO to provide to the Board and the Department, before substation construction:

A) the baseline noise measurements at all of the NRP substations;

B) estimates of noise levels that could be expected after the project is constructed;

C) VELCO's evaluation as to whether noise mitigation is required at any of the substations and its plans for undertaking this mitigation, including relevant sound level specifications for equipment including transformers, PARs, and dynamic reactive devices.

The Board should also require post-construction noise measurements at substations as well as specified locations external to the substations to ensure that design specifications have been met. Further, the Board should require VELCO to take all reasonable steps to address noise concerns identified by the public.

Need for the Proposed Project

Q. Do you agree with VELCO that a substantial Vermont transmission upgrade is needed to reliably serve Vermont load levels up to 1200 MW?

A. Yes. The VELCO transmission system depends on the availability of two important transmission elements in order to meet peak load levels up to 1200 MW. These elements are the PV20 circuit connected to the New York Power Authority's (NYPA's) substation at Plattsburgh and the Highgate converter connected to the Transenergie network of Quebec. These elements, by their very nature, are prone to experiencing long term outages. The Highgate converter is susceptible to a valve hall fire which could require six months or more to repair. During such an outage, the facility would be totally unavailable to the VELCO transmission system in northwestern Vermont. The PV20 circuit, providing VELCO with a 115 kV connection to NYPA's Plattsburgh substation, constitutes the strongest transmission tie to northwestern Vermont. This PV20 circuit contains both submarine and buried cable sections, which upon failure, will require several weeks or longer to reconfigure or repair. Should either of these vital transmission elements be unavailable, under a set of reasonable local generation assumptions and summer load levels, a trip of any of several key circuits connected to NW Vermont will cause either severe voltage problems in the area or overloads of remaining circuits supplying the area.

Q. What do you mean by a set of reasonable local generation assumptions?

A. Regarding generation in northwestern Vermont, and for the purposes of system studies, I believe that it is reasonable to assume the availability of the McNeil generating station in Burlington due to its design and proven reliability. However, it is not reasonable to assume that the existing local combustion turbines or small diesel generating units will be available on a daily basis, at a high duty cycle, and for extended periods. It is reasonable, however, to assume that these units are available in reserve as a backup in the event that the McNeil unit trips. With regard to local hydro electric units, during summer heavy load periods, this hydro power is often limited so it can not be counted upon as a substantial available resource.

Q. What reinforcements are required to reliably meet today's loads?

A. The reinforcements required to meet today's loads include the PV20 PAR, the Blissville PAR, the 115 kV circuit from New Haven to the Queen City substation, reconductoring of the Granite to Barre 115 kV circuit, the Granite PAR, the first phase of Granite STATCOM (dynamic voltage support), and a 230/115 kV transformer plus fixed capacitors at Granite. This group of upgrades comprises over roughly 2/3 of the estimated project cost.

Q. What reinforcements are required to reliably meet state-wide loads of 1200 MW?

A. The additional elements of the NRP, including an additional circuit from West Rutland to New Haven, and additional dynamic voltage support at the Granite substation are required to provide reliable load service for load levels up to 1200 MW, assuming an extended outage of the Highgate converter.

Q. What are the potential reliability consequences of not doing this upgrade?

A. Should either of the long term outages described above happen, followed by any of a number of probable first contingencies at today's load levels and under the reasonable set of generation assumptions described above, widespread problems will occur due to the inability or "weakness" of the remaining transmission lines to support the load. The area of impact is likely to include all of northwest Vermont and possibly extend further into Vermont. The impacts caused by the contingency include severe sags and possible collapse of voltage. Severe sags down to roughly 85% and below will cause extensive tripping of "customer side" residential, commercial and industrial equipment. Voltage collapse will cause complete loss of load over the area impacted. Restoration from the voltage collapse situation is a complicated process requiring times of up to 24 hours before service can be fully restored to all customers. Clearly, if reliability is inadequate at today's load levels, it will only be worse at load levels of 1200 MW. This will relate to more hours of exposure plus extension of the set of likely contingencies that can cause a severe problem.

Q. Please explain what is meant by "probable first contingencies."

A. Probable first contingencies are any likely event that may occur in normal day-to-day operation of the transmission system and its interconnected equipment that alters the transmission path. An example would be a fault due to lightning causing an insulator flashover or possibly an insulator failure. Additional probable contingencies include failures of transformers, bus sections, and circuit breakers. In addition, the failure of a circuit breaker to clear a fault on a transmission element, requiring operation of a backup clearing system, is also considered to be a probable contingency.

Q. Do you agree with VELCO's assertions regarding the potential for widespread blackouts within Vermont? If not, please explain the basis for your disagreement.

A. While I do think that the "widespread blackouts," referred to in the direct testimony of VELCO witness Tom Dunn, pages 5 and 6, are possible, I believe that their likelihood is lower than predicted by VELCO due to the characteristic behavior of the loads connected to the system. VELCO assumes constant mega-volt ampere (MVA) loading in their analyses. This assumption is commonly used throughout the Northeast in load flow analyses both to simplify the analyses and to provide a reasonably conservative (i.e., err on the safe side) estimate of system performance. This assumption implies that all equipment remains connected to the system and that it draws constant real and reactive power as the voltage sags. This assumption is based on the idea that voltage regulators on the distribution system boost voltage on the distribution side so as to remain constant. In reality, regulators have limits; therefore voltage at the customer side eventually sags thereby reducing the power drain on the transmission system. In addition, at reduced voltages, some sensitive customer equipment including air conditioners, computers, motor contacters and manufacturing tools trip thus causing a further reduction in the loading of the transmission system. An example of such system behavior is the response of the Vermont system during the August 14, 2003 blackout where substantial customer load loss was experienced without the occurrence of widespread blackouts in Vermont.

Q. Yet you state that there is a need for a substantial transmission upgrade; what then is the basis for your assessment of need?

A. Clearly, the loss of customer side equipment cited above has widespread adverse impact on Vermont's residential, commercial and industrial customers and should be avoided. VELCO's use of constant MVA load models provides a good indication that substantial voltage problems will evolve to an extent that will cause widespread hardship. Once the hardship of customer-side equipment loss occurs, I believe that in many cases the collapse will be arrested due to this highly undesirable customer-side involuntary load shedding. Note that voltages will likely sag below values on the order of 85% of nominal on a widespread basis before most of the load relief occurs. This loss of customer-side loads is clearly a situation that should be avoided. With that said, I believe that there are also situations, although less likely than anticipated by the analysis models in use by VELCO, where widespread voltage collapse could occur. Voltage collapse is an even more undesirable situation in that area load loss is total and restoration becomes a lengthy process requiring up to 24 hours.

Q. What are the New England Power Pool (NEPOOL) and the Northeast Power Coordinating Council (NPCC)?

A. NEPOOL is a voluntary association of entities that are engaged in the electric power business in New England. The NEPOOL members, referred to as Participants, include investor-owned utility systems, municipal and consumer-owned systems, joint marketing agencies, power marketers, load aggregators, generation owners and end users. The NPCC is an organization whose mission is to promote the reliable and efficient operation of the interconnected bulk power systems in northeastern North America through the establishment of criteria, coordination of system planning, design and operations, and assessment of compliance with such criteria.

Q. How do NEPOOL and NPCC design and operating criteria relate to this need?

A. The design criteria of NEPOOL require that the transmission system be designed to meet all reasonable contingencies, including the occurrence any first contingency given an extended outage of any critical transmission element or resource. NEPOOL concurs that the Highgate converter and the PV20 circuit possess a reasonable vulnerability to long term outages. This concurrence is evidenced by review of the project studies and assumptions by the various NEPOOL technical committees culminating in their 18.4 (reliability impact) and 15.5 (funding) approval as a necessary reliability addition to the NEPOOL transmission system. NEPOOL operating criteria embrace the same first contingency requirements as the design criteria. As a result, a whole range of measures will be taken ranging from dispatch of out-of-merit generation through voltage reduction and arming of load shedding schemes to avoid the possibility of substantial loss of load and possibly other events including thermal overloads, voltage collapse (blackouts), voltage sags, and generation tripping which in turn may have a cascading impact on the interconnected transmission system.

Considering the potential for widespread severe electrical problems in northwestern part of the state, which represents approximately one half of Vermont's summer peak load, I believe that it is prudent for VELCO to design and operate its transmission system in full compliance with NEPOOL and NPCC criteria. These criteria essentially embody uniform standards of "good utility practice" with regard to reliability and are applied to the bulk power systems of New England and northeastern North America. I simply do not believe that half of Vermont's electrical load (and possibly more) should be subjected to reliability performance that is lower than that enjoyed by all other loads connected to the bulk electrical system of northeastern North America.

Q. Can you comment on the models used by VELCO in the development of the NRP?

A. Yes. As I discuss above, in the design of the NRP, VELCO has studied scenarios in detail, using industry standard analysis and modeling tools, and the best comprehensive system model available. This model includes a detailed model of projected Vermont loads based on information provided by the Department. In addition, it models interconnected systems of northeastern United States with various probable power transfer scenarios. With regard to contingency simulation, VELCO has simulated all possible likely first contingencies including line trips, breaker failures, stuck breakers and bus faults with the backdrop of an unavailability of the Highgate or PV20 sources. Included in this analysis is a critical load level analysis where load levels are increased to a point where the system fails due to a contingency and the appropriate element is added to remedy this failure. In addition, reliability and stability analyses performed by VELCO have been given detailed peer review and approval by the appropriate NEPOOL task forces comprised of industry experts. Considering the detailed level of analysis performed, and the amount of independent review, including my own, I am confident that the NRP design resulting from these studies will meet the need to reliably and efficiently serve load levels up to 1200 MW in the presence of an extended outage of any single element or source, including the Highgate converter or the PV20 circuit.

Q. Do you have any qualifications about your statement that the NRP will serve state-wide loads up to1200 MW?

A. Yes, there is one qualifier with regard to the 1200 MW capability noted above. This 1200 MW level relates to an extended outage of the Highgate source. Should the PV20 source suffer an extended outage, the NRP configuration will reliably serve loads up to approximately 1165 MW. Comparing the outage scenarios of the two critical elements, the Highgate converter extended outage is likely to extend for 6 months or longer whereas the PV20 extended outage (complete unavailability of the circuit) is likely to extend for 2 to 3 weeks.

Therefore, I believe it is more reasonable to focus on the Highgate outage and the resulting ability of the NRP to serve 1200 MW of load.

Q. Are there elements of the NRP that could be deferred and still reliably serve load at some reduced levels?

A. Yes. Based on a review of the critical load level analysis performed by VELCO, there are two potential deferrals: 1) elimination of the second 75 MVAR unit of the Granite STATCOM resulting in a reduced capability of 1140 MW; and 2) elimination of the 345 kV line from West Rutland to New Haven resulting in a reduced capability to 1100 MW. The next stage of reduction would be the elimination of the first 75 MVAR unit of Granite STATCOM which would reduce the capability to 1015 MW or today's load levels. All other elements of the NRP are required to serve load levels up to 1015 MW. The viability of deferring elements of the NRP is discussed in detail in the testimony of Department witness Jonathan Lesser.

Q. Does the proposed NRP provide additional benefits?

A. Yes. In addition to improving the reliability of the Vermont transmission system, the stronger, more stable transmission system resulting from the project will provide a more robust framework with regard to generation, both within the congested area of northwest Vermont as well as providing this area access to generation from elsewhere in Vermont and New England thereby reducing congestion that results from operational reliability constraints.

Cost/Impact

Q. Does the NRP proposed by VELCO represent a least cost design approach in solving the reliability problems?

A. Yes, with regard to equipment and installation cost for the NRP as proposed. In my opinion, the basic substation and line configurations proposed by VELCO meet basic reliability standards without "over-design" or "gold plating." These designs are consistent with those used in the rest of New England to avoid multiple outages due to single equipment failures such as "stuck breakers" or bus faults. This level of contingency design is consistent with practices across northeastern United States and within the NPCC coordinating region. There is one exception where I consider the VELCO's design to be below generally accepted standards. This regards the 115 kV capacitor and STATCOM connections at Granite. I discusses these further below. With respect to costs relating to environmental, aesthetic and other impacts, I have additional comments below under the heading "Alternates."

Q. Are the cost estimates for the proposed NRP reasonable?

A. Yes. I have reviewed the cost estimates provided by VELCO and conclude that none appear to be too high.

Q. Are any of the cost estimates too low?

A. Yes, the two areas that stand out are: 1) the estimates for the Granite substation additions; and 2) the 345 kV line from West Rutland to New Haven.

Q. Why do you believe that the estimates associated with the Granite expansion are too low?

A. I believe that they are too low for three reasons: 1) there is inadequate footprint allocation for both stages of the STATCOM; 2) the cost estimate for the STATCOM appears too low; and 3) the configuration proposed by VELCO for connecting the reactive support to the 115 kV system is inadequate.

With regard to the first item, a review of VELCO's drawing 213-6000 D (refer to VELCO's direct testimony Exhibit DJB-33) indicates that approximately 22,400 sq. ft. is allocated for the +/- 150 MVAR STATCOM device. This area is roughly the same footprint that is required for the existing +/- 75 MVAR STATCOM at Essex (refer to VELCO's direct testimony Exhibit DJB-26). While providing twice the dynamic range of reactive support in the same footprint may be technically possible, it will most likely come at some substantial added cost. Also, minimization of the footprint may limit the selection of available technologies (STATCOM, SVC or synchronous condensers) and/or configurations (modularity, redundancy, component sizing) which could further impact cost in a competitive bidding environment as well as limit performance, reliability and maintainability. In my opinion, the footprint allocation should allow for potential use of any applicable technologies that meet the functional requirements.

With regard to the second item, the "turnkey" cost estimate provided by VELCO (supplemental response to DPS 1-VELCO-13a) is $15 million for a +/-150 MVAR device. My rough estimate for the "turnkey cost" of this size device is on the order of $27 million. This estimate assumes use of solid state flexible alternating current transmission system (FACTS) technology employing power electronics; either STATCOM or static var compensator (SVC) type devices using the same footprint as the existing Essex STATCOM. Although less familiar with synchronous condenser costs, I do not believe them to be significantly different from those of devices using power electronics.

With regard to the third item, the configuration for connecting reactive support to the 115 kV system, as proposed by VELCO, is inadequate from a reliability and maintainability perspective in that 225 MVARs are connected to a single bus and that +/-150 MVARs of STATCOM are connected by a single breaker. The implications of this proposed configuration are discussed in further detail below under the heading Reliability and Stability. Should VELCO address this concern, some additional footprint and cost will likely result.

Q. Is the physical expansion of the Granite substation proposed by VELCO for the NRP adequate?

A. With due consideration to the above, no.

Q. What do you recommend with regard to VELCO's plans for the Granite substation?

A. I recommend that prior to the issuance of a CPG that VELCO be required to: 1) revisit the Granite 115 kV bus configuration and connections to the reactive power equipment and its impact on the yard layout; 2) review and update the STATCOM cost estimate with an eye toward accommodating any of the available dynamic reactive voltage support technologies; and

3) update the estimate of total cost and physical expansion requirements of the Granite expansion and equipment additions. I discuss these recommendations in further detail under the heading of Reliability and Stability.

Q. Do you believe that VELCO's estimated cost for the 345 kV line from West Rutland to New Haven is too low?

A. Yes. VELCO's estimate for the 35.5 mile line section (refer to VELCO's direct testimony, Exhibit TD-21) is approximately $13.8 million. The per mile cost is therefore on the order of $390,000 per mile. I would estimate that the cost of this construction, in the proposed construction time frame of 2005, be more on the order of $550,000 to $650,000 per mile. This may constitute an adder on the order of $7.5 million to the estimated cost of the NRP.

Q. Does this revised cost for the 345 kV line from West Rutland to New Haven change your recommendations with regard to the NRP?

A. No. This revised cost was considered in the analysis and testimony of Department witness Jonathan Lesser. This adder of approximately $7.5 million does not alter the Department's conclusions or recommendations.

Q. Do the revised costs affect the ability of VELCO to receive pool transmission facility (PTF) funding for this project?

A. No. VELCO's current estimates for the cost of the NRP are approximately $122 million. VELCO received approval from NEPOOL for a project cost of $156 million. The revised cost estimates would not impact VELCO's ability to receive PTF funding.

Alternatives for the NRP Generally

Q. What transmission alternatives were considered and analyzed by VELCO in their development of the proposed NRP?

A. The primary alternatives considered and analyzed by VELCO include: 1) Upgrading the PV20 circuit to 230 kV; 2) Making the Highgate Converter redundant; and 3) Using 115 kV for the added new circuit from West Rutland to New Haven. These are discussed in detail in VELCO's direct testimony (refer to Exhibit Planning 8).

Q. Do you agree with VELCO that these alternatives are inferior to the proposed NRP?

A. Yes, I do. Alternatives 1) and 2) above were likely conceived to provide coverage for extended outages of the Highgate converter. However, when one considers extended outages of the PV20 circuit, neither of these alternatives provide the desired reliability coverage required. Alternative 1), upgrading the PV20 to 230 kV, only strengthens this source but provides no backup for its extended outage. To do this, the existing 115 kV circuit would have to be retained. Retaining the existing 115 kV circuit from Plattsburgh would present some substantial challenges regarding cost, aesthetic and environmental impacts. Alternative 2), making the Highgate Converter redundant, also does not provide backup for extended outages of the PV20.

Alternative 3) does work in that, according to VELCO's analysis, it performs adequately for load levels up to 1200 MW. This alternative would eliminate the need for 345 kV from West Rutland to New Haven to achieve a 1200 MW capability. However, a serious drawback to this option is that it does not set the stage for future upgrades of the transmission system to achieve 1400 and 1500 MW capabilities. In addition, it requires the addition of a transmission circuit from Granite to Middlesex. On this basis, I agree with VELCO's conclusion that this option should not be pursued further at this time.

Q. Did you consider transmission alternatives to the NRP beyond that which was considered by VELCO?

A. Yes. I considered possible alternatives to the New Haven to Queen City transmission line and West Rutland to New Haven transmission line.

Alternatives for the New Haven to Queen City 115 kV Line

Q. Please describe the alternative that you considered to the proposed 115 kV transmission upgrade from New Haven to Queen City.

A. I considered an alternative that involves rerouting the 115 kV line using the existing VELCO corridors between the New Haven and Queen City via the VELCO Williston substation.

Q. Why did you consider this alternative?

A. I considered this alternative because VELCO's proposed route faces several challenges including: 1) exposure to distribution substation equipment failures and exposure to local distribution system faults; 2) aesthetic impacts, and potential costs of mitigating those impacts; 3) VELCO's need to acquire additional 100 ft. right-of-way (ROW) easements; and 4) the likelihood that VELCO will be required to proceed with condemnation, and the costs and time delays associated with such condemnation. Considering these challenges, it seemed prudent to further explore this alternative.

Q. Please describe the alternative that you analyzed.

A. This alternative routes the new 115 kV circuit required for reliability using the existing VELCO corridor from New Haven to Queen City via VELCO's Williston substation. In addition, the existing 34.5 kV circuit would be rebuilt using larger conductor to more reliably serve the four distribution substations in the New Haven to Queen City corridor.

Q. What advantages would this alternative provide compared to the proposed route?

A. The advantages of this alternate include the following: 1) Use is made of existing VELCO right of way; 2) there is probably no need to widen the corridor to accommodate the new 115 kV circuit (this needs further field verification due to the specific impact of terrain - in some instances special considerations may be required with regard to danger trees); and 3) this path generally encounters areas of lower population density. Also, it should be pointed out that this alternative offers less exposure to substation termination equipment failures (lightning arresters, insulators, potential transformers, circuit switchers) as terminations in the distribution substations are avoided. Another electrical advantage is that since this alternative avoids direct connection to distribution lines via a single transformation, local distribution faults will have less impact on the voltage of the 115 kV transmission system.

Q. Are there disadvantages to this alternative?

A. Yes. There would likely be an aesthetic impact of adding a second circuit along side of the existing circuit. Also, if a 345 kV line is required in the future to extend north from New Haven, adoption of this alternative would result in two transmission circuits in the New Haven to Williston corridor rather than just one.

Q. After consideration, do you recommend that this alternative be pursued?

A. No. After careful consideration, I believe that VELCO's proposal provides the greatest benefits among the available alternatives.

Q. Please explain.

A. First, VELCO's proposal efficiently solves multiple electrical problems with one 115 kV circuit replacing the existing 46 kV circuit from New Haven to Vergennes and the 34.5 kV circuit from Vergennes to Queen City. This 115 kV addition benefits the VELCO system by extending the needed "fifth transmission path" from the termination of the 34.5 kV line at New Haven, north to the constrained northwest Vermont area.

Second, the 115 kV circuit uses single pole construction to minimize impact and corridor requirements. I discuss further possible enhancements to this single pole construction below.

Third, the existing distribution substations along this corridor are modified to "step down" voltage from 115 kV to the distribution level. This enables all loads on the corridor to be fed for loss of supply at either end, a situation that can not be achieved with the present 34.5 kV configuration at today's load levels. It also reduces transmission losses whose costs are presently born by GMP and CVPS customers.

Fourth, should another transmission line be required in the future to extend the 345 kV further north to join the 230 kV circuit from either Plattsburgh and/or Granite, the 115 kV circuit in the New Haven to Williston corridor could be removed and replaced by an EHV circuit resulting in only 1 transmission circuit between New Haven and Williston in the New Haven to Williston corridor. This is due to the fact that the existing 115 kV circuit could be removed and replaced with the 345 kV circuit.

Underground Considerations

Q. The topic of undergrounding portions of the proposed 115 kV transmission line from New Haven to Queen City has come up during the public hearings. Please describe the advantage.

A. The primary advantage is its lack of aesthetic impact. It takes the line completely out of view. However, depending on the type of cable system used, the structures required to transition the ends of the cable to the overhead line can be relatively unsightly when compared to single pole overhead structures.

Q. Please describe some of the disadvantages of undergrounding.

A. The major disadvantages of undergrounding include: 1) cost; 2) outage times required for repair and circuit restoration; 3) environmental impacts during construction; and 4) system design complications due to the electrical characteristics of underground cable.

Q. What are the cost implications of underground vs. overhead 115 kV circuits?

A. To get a rough idea of cost impact, the installed cost of cable can run on the order $2 million or more per mile depending on many factors including terrain and cable configuration. The cost of overhead is on the order of $250,000 to $300,000 per mile. Therefore, the incremental cost of undergrounding is likely to be upward of $1.7 million per mile.

Q. What about repair and restoration time?

A. For overhead circuits, the response to two types of faults needs consideration. If a fault is temporary, such as caused by a lightning flash over, the circuit is tripped then reclosed (restored) seconds later by an automatic reclosing process. If the fault is permanent, the reclosure reestablishes the fault and the circuit trips a second time and remains open until the problem is located and repaired. Restoration can be achieved in several hours depending on the problem and the nature of the required repair. Roughly 2/3 of the faults at 115 kV are of a momentary nature with successful automatic restoration of the circuit.

For cable circuits, the scenario is different. Cable faults are almost always permanent and due to failure of the cable dielectric insulation. Reclosing onto the fault can cause additional damage to the cable system. Therefore, automatic reclosing and the possibility of automatic rapid restoration is eliminated. This is necessary even if only a portion of a circuit section is underground as the process of accurate fault location takes human intervention (unless the cable is terminated at both ends in substations with circuit breakers and protective relay systems, a substantial cost adder). The fault location process is complicated and can take from several hours to several days before restoration of the healthy portions of the circuit can be achieved. If the fault is in the cable, total end to end restoration of the circuit can take on the order of 2 weeks to achieve.

Q. What is the impact of an extended outage on the VELCO system?

A. If a circuit with cable is a portion of the transmission network, an extended outage possibility is introduced. During this outage, the next probable contingency needs to be covered. In fact, this is one of the very reasons why the NRP is needed - outage of cable portions of the PV20 circuit. If we allow for an extended outage of the New Haven to Queen City circuit, it is likely that additional reinforcements beyond those proposed for the NRP will be needed to serve a 1200 MW load level. This results as an additional cost impact beyond the cost of the cable.

Q. What about the construction impact and right of way maintenance requirements?

A. Environmental concerns relate to the severe disturbance created by excavation along every foot of the cable path vs. excavation only at pole locations for the overhead system. A 12 ft. to 20 ft. path along one side of the cable is impacted. Once the cable is installed, a right of way on the order of 50 ft. needs to be retained and maintained to facilitate repair.

Q. What are the design complications regarding use of underground cable?

A. Underground cable has much lower impedance than overhead lines. When used in a network with overhead lines, this impedance affects the distribution of power flowing in the circuits. Impedance mismatch at transition points causes unique transient phenomena when circuits are switched on and off. The cables have a relatively high value of shunt capacitance which can cause voltage issues for longer length applications. None of the above issues are "deal breakers" and therefore can be overcome by one means or another. My main point here is that application of cable as part of a system with overhead transmission requires careful modeling and study to ensure that there are no adverse impacts.

Q. What are your recommendations regarding the use of undergrounding?

A. With due consideration to the above, it is my opinion that use of underground cable as a component in this circuit should be avoided.

Alternative Structure Configurations for the New Haven to Queen City 115 kV Line

Q. Are there other alternatives to VELCO's design, along the proposed routing for the New Haven to Queen City transmission line, that could result in a lower aesthetic impact?

A. Yes. There are alternate conductor configurations that have the potential for mitigating aesthetic impact.

Q. Please describe these alternatives.

A. The alternatives are simply variations on the single pole design proposed by VELCO. They include the following: 1) reduction of span length; 2) reduction in pole height above the topmost conductor attachment; 3) compression of the vertical distance between the conductors; 4) increasing the pole height; and 5) using Corten steel poles where pole color is important. Options 1), 2) and 3) provide reductions in pole height while option 4) raises the height of the conductors so as to reduce the need to remove trees that provide visual screening. Option 5) provides for a long term consistency of color where it is important to blend with the surrounding view.

Q. What pole height reduction can be achieved by Option 1) reducing the span length or length between the structures?

A. Assuming that the 61 ft. poles as proposed corresponds to a span distance of 430 ft., reducing the span to 300 ft., with no other changes, can reduce the required pole height pole height to 55 ft.; a reduction of 6 ft.

Q. Please describe what is involved with Option 2) and the amount of pole height reduction afforded by this option.

A. The proposed design extends the pole approximately 6 ½ ft. above the attachment of the brace of the top insulator. For longer span lengths, this distance allows clearance for ice galloping effects. It also allows ample shielding for lightning protection. In my opinion, this height above the top attachment could be reduced by 6 ft. without degrading the lightning protection significantly below that of existing VELCO designs. In addition, if the span lengths are reduced to distances on the order of 300 ft., the ice galloping problem is mitigated by the reduced sag afforded by these shorter spans. This reduces the chance of flashover between the shield wire and the top conductor.

Q. Please describe what is involved with Option 3) and the amount of pole height reduction afforded by this option.

A. The proposed vertical spacing between conductors on the side of the pole where 2 conductors are located is 12 ft. This provides an equilateral triangle configuration with the single conductor on the other side of the pole. If desired, if accompanied by a reduction in span length, this vertical distance could be reduced to 8 ft., which would result in a pole height reduction of 4 ft. The primary factor is vertical motion of the conductor with regard to a sudden release of ice buildup and motion due to wind induced ice-galloping. As the span is reduced, the potential impact of reducing the vertical distance diminishes. In addition, use of higher conductor tensions can reduce the vertical motion.

Q. Can Options 1) through 3) all be applied to the same structures to achieve an additive reduction in pole height?

A. Yes, they can be combined to achieve a total reduction in pole height on the order of 16 ft. resulting in pole heights on the order of 45 ft. These 45 ft. (above the ground) poles can also be smaller in diameter than the 61 ft. poles in the proposed design. Further reductions in pole heights can be achieved using shorter spans and/or increased wire tensions to further reduce sag. Also, use of ACSS (aluminum clad steel supported conductor) affords reduced sag opportunities over the ACSR (aluminum clad steel reinforced conductor) in primary use by VELCO.

Q. Can the options be applied over short segments of the line?

A. Yes, they can be applied to a segment of line comprised of a few single pole structures.

Q. What do you recommend regarding alternative configurations for the 115 kV line from New Haven to the Queen City substation?

A. I recommend that VELCO utilize the above referenced options where aesthetic mitigation may be warranted. Department witness David Raphael discusses those sections along the corridor where such mitigation is required.

Alternatives for the West Rutland to New Haven 345 kV Line

Q. What types of alternatives did you consider regarding the proposed 345 kV transmission addition from West Rutland to New Haven?

A. I considered alternate structure designs and possible alternate voltage levels.

Q. Why did you consider these alternatives?

A. I noted that the VELCO proposal involved widening the existing corridor for the 345 kV line from West Rutland to New Haven by 100 ft. All but 1.3 miles lies within their existing ROW; so ROW acquisition is not a major issue. I noted that VELCO estimates that some 240 acres of woodland need clearing (refer to VELCO's response to DPS1-VELCO-4) to accommodate the proposed construction. Recognizing that there may be aesthetic and possibly environmental concerns with this widening, I wanted to explore options that would minimize the corridor requirements. Also, I wanted to learn more about the possibilities of adding new lines to existing corridors to minimize the impact of possible future transmission upgrades such as the 230 kV addition from Granite to Middlesex.

Q. Please describe the alternatives that you analyzed to offer potential corridor width reductions.

A. There are several alternatives available to reduce the required corridor width, some of which retain the possibility of constructing the new 345 kV circuit alongside of the existing 115 kV circuit but on separate structures so as to achieve the electrical performance afforded by the proposed configuration. See Exhibit DPS-GES-2 for representative drawings.

1) Reduce the clearance between the new proposed 345 kV H-frame and the existing 115 kV circuit. Previous VELCO plans assumed a corridor width of 225 ft. vs the 250 ft. as proposed. In fact, approximately 20 miles of the existing 345 kV/115 kV double circuit from Coolidge to West Rutland use a 235 ft. corridor. This would reduce the distance between the circuit centerlines and the distance between the closest phases of adjacent circuits. VELCO Exhibit DJB-8, Cross Section 1, shows VELCO's proposed configuration requiring a 250 ft. corridor. The corridor width could be reduced by reducing the 80 ft. distance between the circuit centerlines.

2) Use a single pole delta configuration for the 345 kV circuit. The required corridor

expansion is reduced by on the order of 60 ft. (40 ft. additional required). This amount of corridor reduction assumes a level terrain cross section perpendicular to the line. One possible configuration is one provided by VELCO as a response to DPS Information Request 2-50 (refer to Exhibit DPS-GES-2(a)). This configuration uses steel poles with davit arms and V string insulators. Also, a braced pole insulator configuration could be substituted for the davit arm/V string configuration to more closely resemble the 115 kV single pole construction proposed for the New Haven to Queen City circuit (refer to Exhibit DPS-GES-2(c)). The structures could be finished using Corten steel if desired.

3) Use of a single pole vertical configuration for the 345 kV circuit. The required corridor expansion is reduced by on the order of 90 ft. (10 ft. additional required). This amount of corridor reduction assumes a level terrain cross section perpendicular to the line. One possible configuration is one provided by VELCO as a response to DPS Information Request 2-50 (refer to Exhibit DPS-GES-2(b)). This configuration uses steel poles with davit arms and V string insulators. Braced post insulators could be used here also.

4) Use a single pole delta configuration for the 345 kV circuit and rebuild the 115 kV circuit to a single pole delta configuration. This configuration potentially eliminates the need to widen the corridor while providing the reduced pole height of Alternative 2 above. One possible configuration is one provided by VELCO as a response to DPS Information Request 2-50 (refer to Exhibit DPS-GES-2(c)). This configuration uses steel poles with davit arms and V string insulators. Braced post insulators could be used here also.

Q. What are the advantages and disadvantages of Alternative 1 (closer spacing of adjacent circuits) compared to VELCO's proposed construction?

A. By more closely spacing the circuits, a reduction of up to 25 ft. in corridor expansion can be achieved while maintaining the low profile H frame design. Cost would not be impacted.

This alternative has potential for either limited sections or more extensive portions of the line. A possible disadvantage that requires further investigation is the impact on maintenance.

Q. What are the advantages and disadvantages of Alternative 2 (single pole triangular configuration) compared to VELCO's proposed construction?

A. The corridor expansion is reduced by approximately 60 ft. Assuming spans are the same as for H frame, pole height is significantly higher. The added pole height could be reduced by shortening the spans. Estimated cost will be somewhat higher than for the proposed configuration. Danger trees will require additional consideration.

Q. What are the advantages and disadvantages of Alternative 3 (single pole vertical configuration) compared to VELCO's proposed configuration?

A. The corridor expansion is reduced by approximately 90 ft. but pole heights are even greater than those of Alternative 2.

Q. What are the advantages and disadvantages of Alternative 4, new 345 kV triangular with rebuilt single pole 115 kV, compared to VELCO's proposed configuration?

A. The required corridor expansion is eliminated while affording the reduced pole height of the triangular configuration. This can reduce the visual impact in certain situations. Matching spans could be used if desired. The 115 kV circuit would resemble that proposed by VELCO for the New Haven to Queen City corridor. There would be an added cost impact on the order of $250,000 per mile over Alternatives 2 and 3.

Q. Can the above variations be applied to some portions of the circuit while retaining the proposed design for the other portions?

A. Yes. I am not aware of any technical reason why any or all of the above could be used to achieve given environmental and/or aesthetic objectives for portions of the line where desired. Any of the above may result in increased cost depending on the situation, the length and the desired result.

Q. What are some of the desirable features of the configuration proposed by VELCO?

A. The 345 kV H frame construction proposed by VELCO achieves a least construction cost solution while offering adequate reliability and minimum structure height (nominally 79 ft.) for this voltage level. It can be referred to as "low profile" EHV construction. This proposed construction configuration is similar to that already in use by VELCO on portions of the double circuit 345kV/115 kV path from Coolidge to West Rutland. Therefore, a significant advantage of this configuration is that all current O&M practices can be applied, without modification, to the proposed new and existing circuits in the corridor.

Q. With consideration to the above, do you recommend that any of these alternatives be pursued?

A. Yes. I recommend that, where aesthetic mitigation is required, VELCO adopt the above referenced alternatives. Alternative 1 has potential for either limited sections or more extensive portions of the line since there is no significant cost impact. Attention would need be paid to impact on maintenance procedures. Alternative 2 is recommended for specific locations where further corridor reduction is desired. Alternative 3 due to its added pole height, and cost is not recommended except possibly for locations where only a few structures are required. Where substantial corridor reduction and/or aesthetic improvement is needed, Alternative 4 is recommended on a limited basis due to its substantial cost impact. Department witness David Raphael discusses those sections along the corridor where such mitigation is required.

Q. What do you recommend for the 1.3 miles where VELCO's present right of way width is limited to 150 ft?

A. For the 1.3 miles of the line where VELCO currently plans to expand its ROW beyond 150 ft., VELCO should consider adoption of Options 1, 2 and 4, in ascending order of cost, depending on the situation at hand. Option 4 offers the only possibility of avoiding acquiring additional ROW.

Q. What else could be done to reduce the corridor width requirements?

A. A more drastic approach would be to use 230 kV instead of 345 kV for this line section. Any of the single pole configurations described above could be implemented with the result that pole heights would be reduced. Corridor width for scenarios 1 and 2 could be further reduced. Another possibility that would minimize all aspects of the impact would be to convert the existing 115 kV H frame to 230 kV by modifying the insulation system and possibly the structures and adding a 115 kV single pole delta configuration next to it. The 230 kV should work electrically, but has not been studied by VELCO. The question is how much reinforcement would be required at other locations to make it work.

Q. What are the drawbacks to using 230 kV for this line section?

A. There are several drawbacks. Besides possibly requiring additional reinforcements, it introduces the need for an additional voltage transformation at West Rutland. A 230 kV circuit has higher impedance and higher losses than a 345 kV circuit. Although it would interface directly with potential connection to a 230 kV source from Plattsburgh and/or a 230 kV source from Granite, it may limit the ultimate load serving capacity of these potential future considerations.

Q. With consideration to the above, what is your recommendation involving the 230 kV options described above?

A. On the West Rutland to New Haven corridor, further consideration of any of these 230 kV options is not recommended at this time.

Reliability and Stability

Q. Does VELCO's proposed NRP design in general provide adequate reliability?

A. Yes. As I mentioned above, in the design of the NRP, VELCO has studied scenarios in detail, using industry standard analysis and modeling tools, and the best comprehensive system model available. This model includes a detailed model of projected Vermont loads based on information from the Department. In addition, it models interconnected systems of northeastern United States and Canada with various probable power transfer scenarios. With regard to contingency simulation, VELCO has simulated all possible likely first contingencies including line trips, breaker failures, stuck breakers and bus faults with the backdrop of an unavailability of the Highgate or PV20 sources. In addition, reliability and stability analyses performed by VELCO have been given detailed peer review and approval by the appropriate NEPOOL task forces comprised of industry experts. Considering the detailed level of analysis performed and the amount of independent review, I am confident that the NRP design resulting from these studies will meet the need to reliably and efficiently serve load levels up to 1200 MW in the presence of an extended outage of the Highgate source.

Q. Are there any areas where the proposed NRP design is deficient?

A. Yes, there is one area that concerns me and that is the architecture of the 115 kV connections to the reactive support provided at Granite.

Q. What are your concerns with the design of the Granite substation expansion and it's potential impact on reliability?

A. My concerns relating to the proposed configuration connecting the reactive support are as follows: 1) 225 MVARs, comprised of 75 MVARs of fixed capacitors and 150 MVARs of STATCOM, are all connected to a single 115 kV bus; and 2) 150 MVARs of STATCOM reactive support is connected to this bus with a single 115 kV breaker. Under stressed conditions, loss of 225 MVARs of reactive support due to a single contingency could have severe adverse impact on voltages in the area.

Q. Why do you think VELCO would propose such a design?

A. My understanding of VELCO's rationale is that this level of reactive support at Granite is assumed only to be required during extended outages of either Highgate or PV20 and in the event of a further contingency such as the contingency loss of 345 kV from Vermont Yankee.

Therefore, VELCO believes that loss of reactive support at Granite constitutes a higher level of contingency than is necessary to plan or design for. While I think this is reasonable within the planning vision for the NRP, I think that other situations may arise in the future, either during the horizon of the NRP or beyond, during the useful life of the Granite equipment, that may involve more extensive outages of resources, connection of new resources to the system, etc. Also, the configuration as proposed will likely restrict operational flexibility and reduce maintenance opportunities. In short, although VELCO's effort to minimize cost should be recognized, I don't believe that the proposed design constitutes good utility practice and believe that it is inconsistent with the other proposed NRP additions and similar applications elsewhere in New England. Any modifications to remedy these shortcomings, if deferred to the future, will be difficult and much more costly.

Q. What do you recommend that VELCO do to correct this deficiency?

A. I recommend that VELCO: 1) distribute some of the fixed capacitors to other locations on the 115 kV ring bus; and 2) connect the two 75 MVAR STATCOM modules into the bus work with separate 115 kV breakers. The added cost of these changes should be relatively modest compared with the overall cost of the Granite expansion.

Q. What impact will the proposed NRP have on system stability?

A. Stability of the system with addition of the NRP will be enhanced in two ways. First, voltage stability will be improved due to the addition of the dynamic support provided by the STATCOM addition at Granite plus the added stiffness provided by the 345 kV line addition from West Rutland to New Haven. Angular stability of interconnected Vermont generators will be enhanced by the added stiffness afforded by the 345 kV addition. The added voltage stability noted above will also reduce reactive demands on this generation during contingency conditions thereby reducing the chances of their tripping during severe contingencies.

Operational Impacts

Q. What are the potential operational impacts of the NRP?

A. The NRP will substantially benefit operation of the VELCO system in the following ways:

1) With either Highgate or PV20 out of service, reliable operation at load levels up to 1200 MW or 1165 MW, respectively, can be sustained without relying on combustion turbines except in the case of forced outages of McNeil.

2) With both Highgate and PV20 available, the NRP eliminates the need for running “out of economic” generation for reliability reasons.

3) Under all conditions, the NRP greatly expands the opportunity for VELCO to perform both preventative and corrective maintenance on the transmission system. In addition, maintenance opportunities for local generation are expanded.

4) By electrically strengthening the system, existing power electronics based devices on the system (the Highgate Converter and the Essex FACTS device) will suffer fewer transient events resulting in an overall improvement in power quality to connected residential, commercial and industrial customers. Voltages on the system will be more stable under transient events (a particular benefit to voltage sensitive customers).

5) By electrically strengthening the system, the ability to carry loads normally connected to the Quebec system will be improved for the situation involving loss of either or both of the 120 kV Quebec sources.

6) The line additions included as part of the NRP will provide a significant reduction in electrical losses with Highgate and PV20 in service. With either of these elements out of service, the loss savings will be much greater.

7) Should future transmission expansion be required, the NRP will enhance opportunities to take outages for construction and commissioning of these new facilities.

8) Should future generation be located in Vermont, the NRP will provide a more robust transmission platform to interconnect this generation to the VELCO network.

Safety

Q. At public hearings on the NRP, concerns were raised with respect to the safety of the proposed transmission lines. Specifically, some members of the public were concerned with the possibility of poles failing and energized lines falling to the ground thereby becoming a safety hazard. Do you believe that the proposed transmission lines would be safe?

A. Yes I do, for the following reasons: First, the proposed transmission lines would be constructed consistently with the National Electric Safety Code (NESC). I note that compliance with the NESC meets the construction safety standards for Vermont electric systems established by the Public Service Board in its Rule 3.500. Second, in the case of the 115 kV line proposed for the New Haven to Queen City corridor, new infrastructure would replace components that, in some instances, are forty or more years old and approaching the end of their useful lives. This new infrastructure should make the proposed line less susceptible to failure than the existing line. Third, I note that VELCO employs a four-year tree trimming cycle for its transmission system. This tree trimming cycle is the most aggressive cycle used by any Vermont electric utility and would minimize the occurrence of damage to the lines from adjacent trees. Fourth, VELCO patrols its transmission lines on a regular basis. The patrols include infrared surveillance of the lines which detect "hot spots" which are an indication of incipient failure of mechanical connections. As such, VELCO would be able to promptly identify and repair any deficiencies it found in order to limit the occurrence of component failures. Finally, VELCO would monitor its lines automatically with state-of-the-art relays and protection systems. These systems are fully redundant and, if needed, switch off the power to a fallen line in fractions of a second.

Audible Noise Impacts

Q. Is VELCO addressing potential audible noise impacts of the NRP?

A. Yes. VELCO has hired Resource Systems Group (RSG) to take baseline noise measurements at all of the NRP substations. RSG will then model the proposed substations and provide estimates of noise levels that could be expected after the project is constructed. VELCO will then perform an evaluation as to whether noise mitigation is required at any of the substations. (See VELCO Response to First Set of Information Requests by DPS, October 3, 2003, #57, pp. 86-87 of 139.)

Q. What recommendations do you have for the Board with respect to potential noise impacts of the NRP?

A. I would recommend that the Board require VELCO to provide, to both the Board and the Department before substation construction: 1) the baseline noise measurements at all of the NRP substations; 2) estimates of noise levels that could be expected after the project is constructed; and 3) VELCO's evaluation as to whether noise mitigation is required at any of the substations and the plans for undertaking this mitigation, including relevant sound level specifications for equipment including transformers, PARs, and dynamic reactive devices. Careful attention should be given to "tonal noise" or noise within a coherent frequency band. This type of noise can be particularly irritating and can propagate in unusual ways. In addition, the Board should require post-construction noise measurements at substations as well as specified locations external to the substations to ensure that design specifications have been met. Further, the Board should retain jurisdiction to require VELCO to take all reasonable steps to address noise concerns identified by the public, as a result of the NRP, that have not been addressed in the evaluation and mitigation described immediately above.

Optimal Construction Sequencing

Q. Is the proposed construction plan optimal with regard to providing benefits consistent with the growing need?

A. In most areas, yes. The one area of concern is the construction of the 345 kV line prior to construction of the 115 kV line from New Haven to Queen City. The 115 kV construction lags due mostly to the requirement for ROW acquisition for this line. The 345 kV line is not needed until the 1100 MW load level whereas the 115 kV is needed now. VELCO plans to start first on the 345 kV construction in order to spread project resources over the anticipated construction period. Therefore, delaying the 115 kV from New Haven to the Queen City substation results in an additional year of reliability exposure. Considering the amount of construction required in a relatively short time frame, and the time required to obtain ROW for the 115 kV line, it is reasonable to proceed with the 345 kV construction. Having the 345 kV line in service should provide added strength to the system thereby enabling outage opportunities for other aspects of construction and commissioning.

Losses and Efficiency

Q. What effect will the NRP have on overall operating efficiency of the VELCO system in terms of losses?

A. VELCO's estimates of loss savings (refer to response to DPS-VELCO 1-12d) under a plausible set of assumptions with the NRP in service versus the existing system configuration, both with Highgate in service, are 23,800 MW-hrs. for 2006 and 39,400 MW-hrs for 2012. Dividing these numbers by 8760 hrs. yields average values of 2.72 MW for 2006 and 3.11 MW for 2012. Should either Highgate or PV20 be out of service for an extended period, these loss savings afforded by the NRP would be substantially higher due to increased flows into the constrained northwest Vermont area. Therefore, the NRP has the potential for providing significant loss savings.

The August 14, 2003 Blackout

Q. Do the events of the August 14, 2003 blackout have any impact on your conclusion regarding the need for the NRP?

A. No.

Q. Why is that?

A. I believe that NRP is needed because of probable contingency situations that can occur in Vermont. The blackout experienced on August 14, 2003 was an extreme contingency event that was caused by a cascading set of contingencies outside of Vermont.

Q. Do the events of the August 14, 2003 blackout have any impact on your conclusions regarding the adequacy of the design of the NRP?

A. No. Generally, I believe that attempts to design transmission systems to withstand extreme contingency events such as the August 14, 2003 blackout are an exercise in futility in that a huge number of possibilities exist and the ability to accurately simulate their impact on candidate designs is accordingly complex.

Planning Concerns

Q. In your review of the proposed NRP, did you note any concerns with VELCO's planning of the project?

A. Yes. I noted that VELCO's planning process relied on the extensive use of dynamic shunt compensation (STATCOMs) to provide voltage support and PARs to control power flows to optimize network performance. This is a concern because STATCOMs are relatively costly devices and PARs, if they fail, become unavailable for relatively long periods of time.

Q. Do these concerns that you have noted have a material effect on your recommendations for the proposed project?

A. No. As part of its investigation, the Department requested VELCO to perform several simulations, using load flow models, to investigate whether the use of series compensation could replace the proposed Granite PAR and the second stage of the proposed Granite STATCOM. Series compensation is the use of capacitors, placed in series with the transmission circuit, for the purpose of reducing impedance. Series compensation is generally less costly than STATCOMs and PARs. Also, failure of series compensation generally would not result in as long of outage times as failure of STATCOMs or PARs. The results of the simulations, however, indicated that for the proposed NRP, the use of series compensation could not effectively replace the Granite PAR and second stage STATCOM. As such, I conclude that VELCO's reliance on the use of STATCOMs and PARs has no material effect on the proposed NRP.

Q. Does this conclude your testimony?

A. Yes.